

CLAIMS

1. (Currently Amended) A medical image processing apparatus for generating a medical image of a target vessel by using three-dimensional volume data representing a portion in a living body, said apparatus comprising:

a volume data obtaining unit which obtains predetermined three-dimensional volume data including a tubular tissue of the target vessel;

a region specifying unit which specifies a region including a position on the tubular tissue in the three-dimensional volume data at each of a plurality of such positions ~~region~~ as said region specifying unit specifies a planar region which orthogonally intersects with the longitudinal direction of the tubular tissue, said region specifying unit establishing an orthogonal cross sectional region orthogonal to the longitudinal direction of the target vessel by marching along the target vessel in a marching direction ~~without having first determined a center point of each vessel~~;

an extraction unit which extracts information on the tubular tissue in each of the specified regions;

a parallel region specifying unit which specifies a first parallel region and a second parallel region along the target vessel at each of said positions wherein the parallel regions are perpendicular with each other and perpendicular with the orthogonal cross sectional region at each position;

a parallel region extraction unit which extracts information on the tubular tissue in each of the specified parallel regions;

a marching direction determination unit for determining the marching direction based on the information on the tubular tissue extracted from each of the specified parallel regions;

a center specifying unit of said extraction unit for specifying a center position of a

cross section of the tubular tissue in each of the plurality of regions specified by said region specifying unit; and

a medical image generating unit which generates a medical image representing the tubular tissue, based on the information extracted by said extraction unit.

2. (Previously Presented) The medical image processing apparatus according to claim 1, wherein:

each of the plurality of regions are specified by said region specifying unit based on the three-dimensional volume data obtained by the volume data obtaining unit; and

a center line specifying unit which specifies a center line of the tubular tissue in a longitudinal direction of the tubular tissue, based on the plurality of center positions specified by said center specifying unit.

3. (Previously Presented) The medical image processing apparatus according to claim 2, wherein:

said region specifying unit sequentially specifies regions along the tubular tissue; and

said center specifying unit specifies a center of a cross section of the tubular tissue in each of the regions sequentially specified by said region specifying unit.

4. (Previously Presented) The medical image processing apparatus according to claim 2, wherein:

said center specifying unit specifies a center position of a cross section of the tubular tissue in the planar region specified by said region specifying unit.

5. (Previously Presented) The medical image processing apparatus according to claim 2, wherein said extraction unit includes:

a unit which obtains a median point represented by the three-dimensional volume data, of the tubular tissue in each of the plurality of regions specified by said region

specifying unit;

a cross sectional image generation unit which generates a cross sectional image representing a cross section of the tubular tissue at a position of the median point obtained by said unit for obtaining a median point; and

a center specifying unit which specifies a center position of the cross section in the three-dimensional volume data, based on the generated cross sectional image.

6. (Previously Presented) The medical image processing apparatus according to claim 2, further comprising a designation reception unit which receives designation for two arbitrary points on the tubular tissue represented by the three-dimensional volume data, wherein:

said region specifying unit sequentially specifies planar regions which orthogonally intersect with the longitudinal direction of the tubular tissue, at a plurality of positions between the two points along the tubular tissue; and

said center specifying unit specifies a center of a cross section of the tubular tissue in each of the plurality of planar regions specified by said region specifying unit.

7. (Previously Presented) The medical image processing apparatus according to claim 6, wherein:

said designation reception unit receives designation for a planar region which orthogonally intersects with the longitudinal direction of the tubular tissue, at one of the two designated points;

said region specifying unit sequentially specifies points which are apart from one another by a predetermined distance in a direction heading from the one point to the other point of the two points along the tubular tissue, and sequentially specifies planar regions orthogonally intersecting with the longitudinal direction of the tubular tissue at each of the

specified points;

said center specifying unit specifies a center position of a cross section of the tubular tissue in each of the plurality of planar regions specified by said region specifying unit; and

said center line specifying unit specifies a center line of the tubular tissue in the longitudinal direction of the tubular tissue, based on the plurality of center positions specified by said center specifying unit.

8. (Previously Presented) The medical image processing apparatus according to claim 5, wherein:

the three-dimensional volume data includes three-dimensional coordinate information and characteristic information representing a characteristic unique to a substance at each position represented by the three-dimensional coordinate information; and

said cross sectional image generation unit generates an image based on information representing a three-dimensional coordinate position having the characteristic information which satisfies a predetermined condition in the three-dimensional volume data, and clarifies the cross section of the tubular tissue in the image.

9. (Previously Presented) The medical image processing apparatus according to claim 8,

wherein said imaging unit comprises:

a condition changing unit which changes the predetermined condition;

an image attribute detecting unit which detects an image attribute which changes in accordance with changes in the predetermined condition; and

a clarification determining unit which determines whether or not the cross section of the tubular tissue is clarified in an image, based on detected changes in the image attribute.

10. (Previously Presented) The medical image processing apparatus according to claim 9, wherein:

the image attribute represents an area of an image;

said image attribute detecting unit detects an image area which changes in accordance with changes in the predetermined condition, and detects a change in the image area corresponding to the changes in the predetermined condition; and

said clarification determining unit determines whether or not the cross section of the tubular tissue is clarified, based on the detected change in the image area.

11. (Previously Presented) The medical image processing apparatus according to claim 10,

wherein said clarification determining unit determines that the cross section of the tubular tissue is clarified in the image, when an image appearing in a center of the region including the cross section become fit inside the region, and the change in the image area becomes the largest.

12. (Previously Presented) The medical image processing apparatus according to claim 5,

wherein said region specifying unit determines a position of a three-dimensional region to be specified next, based on the three-dimensional volume data which is specified by said center line specifying unit and which represents the center line of the tubular tissue.

13. (Previously Presented) The medical image processing apparatus according to claim 5, wherein:

said center line specifying unit specifies the center line of the tubular tissue as three-dimensional path data; and

said medical image processing apparatus further comprises an image

generating unit which generates an image representing the tubular tissue based on the three-dimensional path data specified by said center line specifying unit.

14. (Previously Presented) The medical image processing apparatus according to claim 13,

wherein said image generating unit comprises:

an image calculating unit which generates plural kinds of images each representing the tubular tissue, and calculates relative positional relationships between the images; and

a display control unit which displays the generated plural kinds of images all at once on a predetermined display device, and displays positional relationships on the displayed images by associating the relations based on the relative positional relationships between the images calculated by said image calculating unit.

15. (Currently Amended) The medical image processing apparatus according to claim 1, wherein:

said region specifying unit specifies a predetermined three-dimensional region whose center is an arbitrary point on the predetermined tubular tissue represented by the three-dimensional volume data;

said region specifying unit also specifies a continuous region at least partially defined within the predetermined three-dimensional region and including the coordinates of the arbitrary point and detects a number of positions at which the continuous region and a surface of the three-dimensional region contact each other;

said medical image processing apparatus further comprises an image clarifying unit which, when the number of positions of contact exceeds a predetermined value, clarifies a three-dimensional image representing only the predetermined tubular tissue in the specified

three-dimensional region, by changing predetermined characteristic information included in the three-dimensional volume data which constitutes a three-dimensional image obtained by data-conversion of said imaging unit; and

said medical image generating unit generates a predetermined medical image representing the predetermined tubular tissue, by using the three-dimensional image clarified by said image clarifying unit.

16. (Previously Presented) The medical image processing apparatus according to claim 15, wherein:

said image clarifying unit comprises

a closed region detecting unit which detects a closed region which constitutes the three-dimensional image obtained by data-conversion of said imaging unit and which includes a center of the three-dimensional region, and

a clarification determining unit which determines based on the closed region detected by said closed region detecting unit and the three-dimensional region whether or not the closed region represents only the predetermined tubular tissue; and

the closed region which is determined by said clarification determining unit as representing only the predetermined tubular tissue is regarded as the clarified three-dimensional image.

17. (Previously Presented) The medical image processing apparatus according to claim 16, wherein:

said closed region detecting unit detects a change in the closed region corresponding to changes in the characteristic information; and

said clarification determining unit determines whether or not the closed region represents only the predetermined tubular tissue, based on changes in the closed region.

18. (Previously Presented) The medical image processing apparatus according to claim 15, wherein:

said region specifying unit specifies a plurality of three-dimensional regions by setting a center of a three-dimensional region to be specified next based on the arbitrary point and/or the clarified three-dimensional image; and

said medical image generating unit generates the predetermined medical image representing the predetermined tubular tissue, by using three-dimensional images clarified in the plurality of three-dimensional regions.

19. (Currently Amended) A medical image processing method for generating an image representing a tubular tissue of a target vessel in a living body by using a computer, said method comprising:

a step of obtaining predetermined three-dimensional volume data including a tubular tissue of the target vessel;

a step of specifying a region including a position on the tubular tissue of the target vessel in the three-dimensional volume data at a plurality of such positions as a planar region which orthogonally intersects with the longitudinal direction of the tubular tissue by marching along the target vessel in a marching direction, said step of specifying a region further including establishing a region threshold and excluding areas beyond said threshold from said planar region thereby distinguishing adjacent vessels from said target vessel;

a step of specifying a first parallel region and a second parallel region along the target vessel at each of said positions wherein the parallel regions are perpendicular with each other and perpendicular with the planar region at each position;

a step of extracting information on the tubular tissue in each of the plurality of specified orthogonal regions and in each of the specified parallel regions;

a step of determining the marching direction along said target vessel based on the information on the tubular tissue extracted from each of the specified parallel regions;

a step of specifying a center position of a cross section of the tubular tissue in each of the plurality of regions specified by ~~said a region~~ regions specifying unit; and

a step of generating a medical image representing the tubular tissue, based on the extracted information.

20. (Previously Presented) The medical image processing method according to claim 19, wherein said step of extracting information on the tubular tissue includes:

a step of specifying a center position of a cross section of the tubular tissue in each of the plurality of specified regions; and

a step of specifying a center line of the tubular tissue in a longitudinal direction of the tubular tissue, based on the plurality of specified center positions.

21. (Currently Amended) The medical image processing method according to claim 20, wherein:

in said step of specifying a region, the regions are sequentially specified along the tubular tissue; and

in said step of specifying a center position, a center position of a cross section of the tubular tissue in each of the regions sequentially specified is specified.

22. (Previously Presented) The medical image processing method according to claim 20, wherein:

in said step of specifying a region, a planar region which orthogonally intersects with the longitudinal direction of the tubular tissue is specified; and

in said step of specifying a center position, a center position of a cross section of the tubular tissue in the specified planar region is specified.

23. (Previously Presented) The medical image processing method according to claim 20, wherein said step of extracting information includes:

a step of obtaining a median point of the tubular tissue represented by the three-dimensional volume data in each of the plurality of specified regions;

a step of generating a cross sectional image representing a cross section of the tubular tissue at a position of the median point obtained in said step of obtaining a median point; and

a step of specifying a center position of the cross section in the three-dimensional volume data, based on the generated cross sectional image.

24. (Previously Presented) The medical image processing method according to claim 20, further comprising a step of receiving designation for two arbitrary points on the tubular tissue represented by the three-dimensional volume data,

wherein:

in said step of specifying a region, planar regions orthogonally intersecting with the longitudinal direction of the tubular tissue are sequentially specified at a plurality of positions between the two points along the tubular tissue; and

in said step of specifying a center position, a center position of a cross section of the tubular tissue in each of the plurality of specified planar regions is specified.

25. (Previously Presented) The medical image processing method according to claim 24, wherein:

in said step of receiving designation, designation for a planar region orthogonally intersecting with the longitudinal direction of the tubular tissue at one of the two designated points is received;

in said step of specifying a region, points apart from one another by a predetermined distance are sequentially specified along the tubular tissue in a direction heading from the one point to the other point of the two points, and planar regions orthogonally intersecting with the longitudinal direction of the tubular tissue at the specified points are sequentially specified;

in said step of specifying a center position, a center position of a cross section of the tubular tissue in each of the specified planar regions is specified; and

in said step of specifying a center line, a center line of the tubular tissue in the longitudinal direction of the tubular tissue is specified based on the specified center positions.

26. (Currently Amended) The medical image processing method ~~apparatus~~ according to claim 23, wherein:

the three-dimensional volume data includes three-dimensional coordinate information and characteristic information representing a characteristic unique to a substance at each position represented by the three-dimensional coordinate information; and

in said step of generating a cross sectional image, an image is generated based on information representing a three-dimensional coordinate position having the characteristic information satisfying a predetermined condition in the three-dimensional volume data, and the cross section of the tubular tissue is clarified in the image.

27. (Previously Presented) The medical image processing method according to claim 26, wherein said step of generating a cross sectional image includes:

a step of changing the predetermined condition;

a step of detecting an image attribute which changes in accordance with changes in the predetermined condition; and

a step of determining whether or not the cross section of the tubular tissue is clarified in an image, based on detected changes in the image attribute.

28. (Previously Presented) The medical image processing method according to claim 27, wherein:

the image attribute represents an area of an image (image area);

in said step of detecting an image area which changes in accordance with changes in the predetermined condition, and detects a change in the image area corresponding to the changes in the predetermined condition; and

in said step of determining whether or not the cross section of the tubular tissue is clarified, based on the detected change in the image area.

29. (Previously Presented) The medical image processing method according to claim 28,

wherein said step of determining that the cross section of the tubular tissue is clarified in the image, when an image appearing in a center of the region including the cross section become fit inside the region, and the change in the image area becomes the largest.

30. (Previously Presented) The medical image processing method according to claim 23,

wherein said step of determining a position of a three-dimensional region to be specified next, based on the three-dimensional volume data which is specified in said step of specifying the center line of the tubular tissue.

31. (Previously Presented) The medical image processing method according to claim 23, wherein:

said step of specifying the center line of the tubular tissue as three-dimensional path data; and

said step of generating an image representing the tubular tissue based on the three-dimensional path data specified in said step of specifying the center line of the tubular tissue.

32. (Previously Presented) The medical image processing method according to claim 31,

wherein said step of generating an image comprises:

a step of generating plural kinds of images each representing the tubular tissue, and calculates relative positional relationships between the images; and

a step of displaying the generated plural kinds of images all at once on a predetermined display device, and displays positional relationships on the displayed images

by associating the relations based on the relative positional relationships between the images calculated in said step of generating plural kinds of images.

33. (Previously Presented) The medical image processing method according to claim 19, wherein:

said step of specifying a predetermined three-dimensional region whose center is an arbitrary point on the predetermined tubular tissue represented by the three-dimensional volume data;

said step of clarifying a three-dimensional image representing only the predetermined tubular tissue in the specified three-dimensional region, by changing predetermined characteristic information included in the three-dimensional volume data which constitutes a three-dimensional image obtained by data-conversion; and

said step of generating a predetermined medical image representing the predetermined tubular tissue, by using the three-dimensional image clarified in said step of clarifying an image.

34. (Previously Presented) The medical image processing method according to claim 33, wherein:

said step of clarifying an image

a step of detecting a closed region which constitutes the three-dimensional image obtained by data-conversion and which includes a center of the three-dimensional region, and

a step of determining based on the detected closed region and the three-dimensional region whether or not the closed region represents only the predetermined tubular tissue; and

the closed region which is determined as representing only the predetermined tubular tissue is regarded as the clarified three-dimensional image.

35. (Previously Presented) The medical image processing method according to claim 34, wherein:

said step of detecting a change in the closed region corresponding to changes in the characteristic information; and

said step of determining whether or not the closed region represents only the predetermined tubular tissue, based on changes in the closed region.

36. (Previously Presented) The medical image processing method according to claim 33, wherein:

said step of specifying a plurality of three-dimensional regions by setting a center of a three-dimensional region to be specified next based on the arbitrary point and/or the clarified three-dimensional image; and

said step of generating the predetermined medical image representing the predetermined tubular tissue, by using three-dimensional images clarified in the plurality of three-dimensional regions.